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CANADIAN PATENT

CONSTRUCTIONAL BUILDING ELEMENTS

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No. OF CLAIMS 12

This invention relates to constructional slab or panel elements for use in buildings and the like.

In the modern building practice it is very desirable to have ducts in the walls and floors to carry heating and lighting conduits, wires and so on. With traditional constructional methods however ducts are not naturally formed and have to be created, if possible, after the floor or wall slab has been cast or erected.

A slab or panel in accordance with this invention comprises at least two sheets each having a regular series of truncated pyramidal or conical dimples which are arranged in parallel rows on a rectangular grid, adjacent sheets being directly fastened together so as to provide, between the dimples of the sheets, two series of parallel ducts extending across the slab at right angles to each other. The ducts which are formed are comparatively large and extending as they do across the panel in two directions at right angles are ideal for carrying the necessary conduits or the like to provide heating and other services. The slabs are light in weight but have a high strength to weight ratio and the weight and cost of material for foundation and supporting members can be substantially reduced as compared with building materials used hitherto.

The dimpled sheets can be made of very many materials for example pressed fibre, a thermoplastic material such as polyvinyl chloride, or a thermosetting plastic such as polystyrene. In all these materials the dimples which can have a circular, square or other polygonally shaped cross section would normally be formed by moulding. If the sheets are made of steel or other metal then the dimples can be pressed out from the plane of the sheet. The slab is often faced with a plane sheet which may be made of a material different from that of the dimpled sheets. For example the dimpled sheets can be made of a very thin material and the facing sheets made of a

rather thicker rigid material. The plane facing sheets provide resistance to damage by point or concentrated loads also compression and tension members in surface planes and they further provide a convenient surface to which to attach electric light switches or the like or for decoration when the slab is being used as a wall or ceiling element.

The cross section of the dimples may be either circular, square or any other polygonal shape.

The sheets can be fastened together by any convenient method depending upon their material for example, if they are made of steel then they can be welded together, if made of pressed fibre they can be rivetted or stuck or in the preferred form both rivetted and stuck together or if made of a thermoplastic material either welded or stuck together with adhesive.

Preferably the maximum dimension of the truncated apices of the dimples is not less than twice as much as the width of the lands or plane portions of the sheets between the dimples so that the dimples on a sheet have a good area of contact either with dimples on another sheet or with a plane sheet. On the other hand the lands must be sufficiently wide to resist tensional forces in the plane of the sheet.

Various slabs in accordance with this invention comprising two or more sheet elements are shown in the accompanying drawings in which:

Figures 1 and 2 are respectively a plan and an isometric view of a sheet element for a slab according to the invention;

Figure 3 is a section on a larger scale taken on the line III-III in Figure 1;

Figures 4 and 5 are sectional views of two forms of two-sheet slabs;

Figure 6 is a sectional view of two interlocked sheets, and

Figure 7 is a sectional view of a four-sheet slab;

Figure 8 is a sectional view of a floor incorporating a two-sheet slab in accordance with the invention;

Figure 9 is a sectional view of an alternative two-sheet slab;

Figure 10 is a diagrammatic view illustrating a clip for joining two sheets together along their side or end edges;

Figure 11 is a diagrammatic plan view showing the interconnection in the same plane of four of the sheets shown in Figure 7; and

Figure 12 is a view similar to Figure 11 but showing an alternative way of joining the four sheets together.

The sheet 1 shown in Figures 1 to 3 has a regular series of conical dimples 2 formed therein the apices 3 of the cones being truncated. The dimples are arranged on the sheet in regular rows and on a rectangular grid so that a series of passageways 4-4 are formed by the lands 5 between the dimples. These passageways extend across the sheet and are also arranged on a rectangular grid. It will be apparent that if the open side of the sheet is

closed, either by a plane sheet or a furthor dimpled sheet or in some other way the passageways will become ducts suitable for carrying wires, pipes etc., as will be explained more fully hereafter. In general the maximum measurement of the truncated apices 3 of the dimples is considerably greater than that of the lands 5 between any two adjacent dimples at their nearest point and the ratio of the diameter of the truncated apices (taking the case of the dimples being cones), to the width of the lands at their narrowest points should not be less than about 2 to 1 so as to ensure reasonable areas of contact between adjacent sheets.

Generally it is unsatisfactory to use unfaced sheets as load bearing elements as they are not very resistant to concentrated loads. Accordingly slabs made of the dimpled sheets would normally have an outer skin 6 (shown in chain lines in Figure 3) on one or both sides. Due to the construction of the inner sheet or sheets the outer skin can be very thin. The sheet 1 can be employed with the truncated apices of the cones facing either upwardly, downwardly or if the slab is to be employed vertically as partitioning, for example, then the apices of the cones will face to one side or the other.

It will be appreciated that both a rectangular grid of ducts 4 having a cross-sectional shape of a truncated cone and a diagonal grid of ducts having a triangular cross sectional shape are present between the cones 2 and the facing sheet or skin 6.

The dimpled sheet can be joined to the facing skins or webs 6 by any convenient method such for example as riveting and/or sticking with adhesive, welding etc., according to the nature of the material employed for the sheet and web.

The sheets can be made of very many materials depending on the use of the resulting slab. For example, they can be made of pressed fibre, steel or a thermoplastic such as polyvinyl chloride. Some sheets in a slab can be made of one material and

ether sheets of a different material. For example the dimpled sheets could be of polyvinyl chloride and the outer facing sheets of pressed fibre which is sufficiently strong and rigid to form the surface of wall panels or the like and/or to have electric light switches or the like attached to it. If a comparatively rigid outer sheet is provided the inner sheets can be as thin as 10/1000 of an inch.

As an example the sheet shown in Figure 1 is made of pressed fibre and is about $\frac{1}{8}$" thick. The depth of the conical dimples is about $1\frac{1}{2}$" and the base angle 60°. The diameter of the truncated apices is about 3".

Two dimpled sheets 1 can be secured together with the truncated apices 3 of the conical dimples 2 of one sheet secured to the truncated apices of the conical dimples of the second sheet as shown in Figure 5 to form a double sheet slab. Alternatively, the plane portions or lands 5 between the conical dimples 2 of one sheet can be secured to the corresponding portions 5 of the other sheet as shown in Figure 4. In either case the sheets may be secured together by, for example, riveting with rivets 7 if the sheets are made of pressed fibre or by any other convenient method. The slab can be faced with an outer skin 6 on one or both sides as desired as shown in Figure 6.

When a slab is made up of two sheets with the apices 3 of the dimples 2 in the two sheets abutting (Figure 5) there is provided between the dimples and within the slab a rectangular grid of ducts 4 having a hexagonal or diamond shaped cross section and a diagonal grid of ducts having a diamond shaped cross section. Such a slab can be used, for example, for partitioning having a height equal to that of a normal room, or floors of normal span finished with wood blocks, boarding or the like or with a concrete top finish.

When a two-sheet slab is formed with the plane portions 5 of the two sheets joined together (Figure 4) then after flat facing sheets 6 have been applied there are present between the dimples, two separate rectangular grids of ducts 4 having a trapezoidal cross section and two separate diagonal grids of ducts having a triangular cross section. This type of slab may also be used for room partitioning and is particularly useful where the ducting on one side is required to be different from the ducting on the other side or where the ducting systems on both sides have to be isolated one from the other.

By the choice of a suitable apex angle, such as 60° as shown in the drawings, and disposition of the conical dimples, two sheets 1 can be assembled with the dimples on one sheet located in the spaces between the dimples on the other sheet to produce a slab such as that shown in section in Figure 6. In such a slab the sheets are interlocked in the sense that they hold each other against relative movement in the plane of the sheets. Any one conical dimple 8 with the exception of those at the edge of the sheet abuts in line contact four conical dimples 10 in the other sheet.

In order to enable two sheets easily and regularly to be assembled in this way it is desirable that each sheet have unequal margins as is shown in Figure 1. When the sheets are to be assembled one is rotated through 180°in the plane of the sheets about a diagonal axis, relatively to the other and then turned over so that the apices of the dimples in one sheet are positioned over a space between the dimples on the other sheet.

When two sheets are thus interlocked, they provide a slab which has good stability in the plane of the slab, good resistance to deflection, and good sound and heat insulation properties. The slab is an evenly balanced assembly which is free from any inherent

tendency to distortion and has an extremely good strength for weight ratio.

An interlocking slab may be faced with a thin web or sheet if desired. When the slab is unfaced with both sides showing recessed cones it is useful for constructions in which acoustic properties are important as a finish for walls and ceilings or a strong, light cellular infilling for doors, panels and the like. When the slab is faced with, for example, pressed fibre, plywood, metal, masonite, fibreglass the material known under the Registered Trade Mark Formica, or other veneering, it is particularly useful as panels, doors, screens, walling, hutting etc.

It will be appreciated that slabs can be assembled from any reasonable number of sheets 1.

As an example a four-sheet slab is shown in Figure 7. In this case the centre two sheets are secured one to the other by joining together the lands 5 between the conical dimples 2 of one sheet to the corresponding portions 5 of the other sheet. Each of the outer two sheets is joined to one of the inner two sheets by securing together the apices 3 of the truncated conical dimples 2 of the outer sheet to those of the inner sheet. Such a slab may be regarded as two of the slabs shown in Figure 5 joined together without facing sheet 6. The outer dimpled sheets have holes formed in them at 12 (these holes are diagrammatically shown and are smaller than they would be in practice) in order to permit riveting of the two inner sheets at 14. The ends of the slab are finished with blocks 15 having a fitment 16 for attachment to an adjacent slab. The four-sheet slab has two rectangular and two diagonal ducting systems similar to those described above with reference to a two-sheet slab and may be used, for example, as load bearing walls, partitions, floors, roofs, decks and the like.

Another example of a multi-sheet slab is a six-sheet slab

and in this case the slab may conveniently comprise three of the slabs shown in Figure 5 without the facing sheets 6 assembled in a manner similar to that illustrated in Figure 7 for a four-sheet slab.

In order to allow the various sheets of a six-sheet slab to be secured together, it is very desirable that all the sheets, except the innermost or central two sheets have holes formed in them to allow the relatively inner sheets to be rivetted or otherwise fastened together. The two outer sheets have twice as many holes as the sheets lying next to them, hereafter called the middle sheets, to enable the central sheets to be fastened together and to enable the middle sheets to be fastened to the central sheets. Half the holes in the outermost sheets are punched in the apices of the truncated conical dimples and are arranged to coincide or be located directly above or below the holes in the middle sheets so as to give access to the two central sheets to enable these to be rivetted together. The other half of the holes in the outermost sheets are punched in the flat plane portions and these holes give access to enable the middle sheets to be rivetted to the central sheets.

A six-sheet slab may for example be used as load bearing walls, partitions, floors, roofs and decks. A six-sheet slab is of course stronger than the four-sheet slab thereby allowing larger distances to be spanned or greater loads to be used thereon.

If desired one multi-sheet slab may be secured to another multi-sheet slab by interlocking the two outer sheets of the two slabs together. The slabs can be kept joined in position in some cases by their own weight or a superimposed load. In some cases, however, it is desirable to secure them by adhesion, by bolting through, or by central wires or rods passing through pre-punched apertures in the cone sides.

The strength of a slab may be considerably increased by

having at critical levels two sheets which are interlocked together in the manner described with reference to Figure 6.

In some cases it may be desirable further to grade the density of the slab so that this is a maximum at one or both outer face or faces and a minimum in the centre or one face, as the case may be. This may be achieved in various ways such as for example by employing sheets of different thickness by increasing the thickness of the outer skin, by providing two or more interlocked sheets at the outer faces of the slab or by varying the depth of the cones. The lattermost feature of varying the cone depth can also be used to vary the depth of the slab and the cones of two abutting sheets may not be of the same depth.

Wherever concrete is used with a slab in accordance with this invention then the top facing sheet 4 is preferably omitted to expose the conical dimples so that concrete or other topping fills the dimples, when it is cast onto the slab. The casting will normally be done in-situ and the slabs can be made sufficiently strong to carry the weight of the concrete or topping when wet and thus save the necessity for having shuttering. If say $1\frac{1}{2}$" of concrete is cast on top of the slab it forms an integral part of the slab increasing its depth and also providing an increased resistance in the plane of compression where it is most required. When concrete sets in the conical dimples it locks with the slab and displacement from the slab in the plane of the slab is resisted by the resistance of the concrete, due to its weight, to upward movement out from the dimples.

Normally to compensate for the removal of a top facing sheet an additional facing sheet is secured to the bottom of the slab or alternatively the thickness of the bottom facing sheet is increased, in order to provide sufficient increase in tensile strength, corresponding to the compression on the top face of the slab.

A two sheet slab forming part of a floor is illustrated in Figure 8. The slab comprises two dimpled sheets having the truncated apices 3 of their conical dimples connected together by rivets in a manner similar to that described with reference to Figure 5. The lands 5 between the dimples of the uppermost sheet in the slab can be connected together in rows in one direction by bars or slats 18 which are fastened to the sheet by for example rivets 20. These bars increase the compressive strength of the top of the slab prior to the casting of the concrete 22 on top of the slab during the casting and until the concrete sets whereupon they provided a further permanent key between the set concrete and the slab as well as increasing the compressive strength of the top.

The upper surface of the concrete which is cast above the slab provides the floor surface and it will be appreciated that the ducts 4 in the slab pass through the floor in two directions at right angles and can be used to carry heating or lighting conduits, wires and the like.

Two sheets having cones of different depths but of the same base angle can be assembled together as seen in Figure 9. In this case the cones 26 of one sheet are placed within deeper cones 24 of another sheet. The truncated apices 3 of the cones of the two sheets are equal in diameter and fit snuggly together but a space or duct is left between the lands 5 of one sheet and those of the other sheet. This duct can again be used for heating and lighting conduits or other purposes. Indeed in this arrangement two ducts are provided separated by the base 5 of the sheet with shallower cones. This can be very useful when it is desired to separate conduits used for different purposes. It will further be appreicated that one series of ducts say that formed between the shallower dimples can be used for conduits and the like running in one direction and the other series of ducts

(that between the deeper dimples) for conduits running in a direction at right angles thereto. The two sheet slab can be faced, if desired, with plane facing sheets above and below or it can have concrete cast directly on to it. Alternatively the width of the lands can be kept constant and the width of the truncated apices varied and this is preferable for some purposes.

The edges of the sheets of two slabs which are located side by side may be joined by means of a clip such as that shown in Figure 10 having a strip 26 extending over the sheets at the joint and two spring arms 28 one engaging the underside of the base and cone side of one sheet and the other the underside of the base and cone side of the adjacent sheet. Alternatively any number of sheets arranged like the four sheets 34, 36, 38, 40 similar to the sheet 1 shown in Figure 1 can be joined together as seen in Figure 11. Each sheet has two of its edges formed with a flange 30 which is at a slightly lower level than the remainder of the sheet the difference in level being equal to the thickness of the sheet, the corners between the flanges 30 and the remaining edges being cut away as indicated at 32 (Figure 1). The sheet 34 has its corner between its non flanged sides, placed at the centre of the four sheet assembly its flanged edges extending along its lower and right hand side. The sheet 36 immediately above the sheet 34 as seen in Figure 11 has one of its cut away corners 32 present at the centre its lower flanged edge 30 extending under the edge of the adjacent sheet 34. The sheet 38 to the left of the sheet 36 has the corner between its flanged edges, present at the centre of the assembly and lying below the corner of sheet 34, the right hand flanged edge extending under the left hand edge of the sheet 36. The sheet 40 has its cut away portion 32 between its flanged right hand edge and its plane upper edge, present at the centre, the right hand flanged edge 30 extending under

the plane edge of the sheet 34 and its upper plane edge extending over the lower flanged edge 30 of the sheet 38. In this way a compact joint is provided with the sheets lying in the same plane with the exception of the overlapping marginal portions which can be stuck or rivetted or otherwise fixed to the underlying flange portions.

An alternative way of fastening four sheets together is to provide a subsidiary joining sheet. This arrangement is illustrated in Figure 12. Four sheets 42, 44, 46, 48 having plane edges are placed edge to edge and a joining sheet 50 is placed over the centre point with the dimples 52 thereof extending into dimples 54 of each of the sheets being joined. The joining sheet can for example be made of a thin thermoplastic material such as polyvinyl chloride so that a water proof joint is achieved. The joining sheet need in fact only engage in one or even half of a dimple in each of the four sheets being joined and will be secured to the sheets by any convenient method. In some cases it is not necessary to provide a definite connection between the sheets, as for example, if concrete is cast on to the sheets the weight of the concrete holds the dimples of the joining sheet firmly engaged in the dimples of the sheets being joined.

Slabs made in accordance with the invention are light in weight and therefore reduce the weight and cost of materials for foundations and supporting members. They can easily be handled in fairly large sizes and can be used as a permanent shuttering for concrete. All those slabs which have an uninterruped rectangular and diagonal duct system are particularly useful when heating and other services are to be provided, either during erection or after erection as the ducts may carry heat or lighting conduits or wires or reinforcing bars or pre- post- tensioning wires or be used for any other desired purpose.

The ducts between any two sheets of a slab are comparatively

large because there is no intermediary plane sheets between the dimpled sheets being joined. The sheets have comparatively large strength in tension in the plane of the sheets due to the width of the lands 5 and a great economy of material is achieved as compared with other constructions of slabs having the same strength.

In one application of a slab in accordance with the invention the ducts may contain electric discharge lighting tubes. Alternatively the ducts may be sealed or arranged to act as the evacuated or gas-filled chamber of electric discharge lamps. In each case the sheets of the slab on at least one side of the ducts would be made of translucent material so that an illuminative effect, visible from one side of the slab, is obtained.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A panel comprising at least two sheets each having a regular series of truncated pyramidal or conical dimples which are arranged in parallel rows on a rectangular grid, adjacent sheets being directly fastened together so as to provide, between the dimples of the sheets, two series of straight parallel ducts extending across the panel at right angles to each other, and a third series of parallel ducts extending in straight lines across the panel at angles other than a right angle to the two perpendicular series, the maximum measurement of the truncated apices of the dimples being equal to, or greater than, the width of the flat lands between the dimples.

2. A panel as claimed in claim 1 in which the maximum dimension of the truncated apices of the dimples of a sheet is not less than twice as much as the width of the lands between adjacent dimples.

3. A panel according to claim 1 consisting of two sheets the truncated apices of one sheet abutting and being fastened to the truncated apices of the other sheet.

4. A panel according to claim 1 consisting of two sheets the lands between the dimples of one sheet being fastened to the lands of the other sheet.

5. A panel comprising at least two sheets each having a regular series of truncated pyramidal or conical dimples which are arranged in parallel rows on a rectangular grid, adjacent sheets being directly fastened together so as to provide between the dimples of the sheets, two series of straight parallel ducts extending across the panel at right angles to each other, and a third series of parallel ducts extending in straight lines across the panel at angles other than a right angle to the two perpendicular series, the maximum dimension of the truncated apices of the dimples of a sheet being not less than twice as much as the width of the lands between adjacent dimples.

6. A panel according to claim 5 consisting of two sheets of the dimples on one sheet being similar to but shallower than the dimples of the other sheet, the shallower dimples being engaged within the deeper dimples.

7. A panel according to claim 5 comprising an even number of sheets, the apices of the dimples of each sheet being fastened to the corresponding apices of the dimples of an adjacent sheet.

8. A panel according to claim 5 comprising an equal number of sheets, the lands of alternate sheets being fastened to adjacent sheets and the truncated apices of the dimples in alternate sheets being also fastened together.

9. A panel comprising an even number of sheets each having a regular series of truncated pyramidal or conical dimples which are arranged in parallel rows on a rectangular grid, adjacent sheets being directly fastened together so as to provide between the dimples of the sheets, two series of straight parallel ducts extending across the panel at right angles to each other, and a third series of parallel ducts extending in straight lines across the panel at angles other than a right angle to the two perpendicular series, the outermost sheets and intermediary sheets having holes in them so positioned as to allow the relatively inner sheets to be fastened together, the maximum measurement of the truncated apices of the dimples being equal to, or greater than, the width of the flat lands between the dimples.

10. A panel as claimed in claim 8 or 9 having a plane sheet fastened to one or both faces.

11. A panel as claimed in claim 1, 5 or 9 having slats extending across and connected to the apices of the dimples or the lands of one or more rows of the uppermost sheet.

12. A dimpled sheet for use in a panel as claimed in claim 1, 5 or 9 wherein at least two of the marginal edge portions are depressed to form a flange in a plane different from that of the remainder of the sheet, the corner portions between the depressed flanges and the other edges being cut away.

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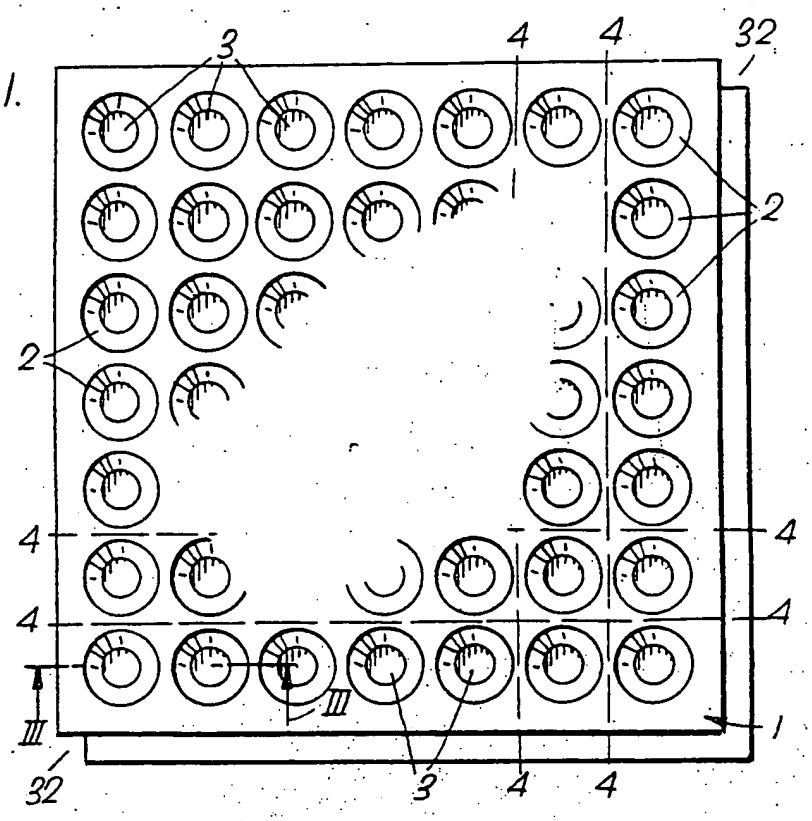
Fig.1.



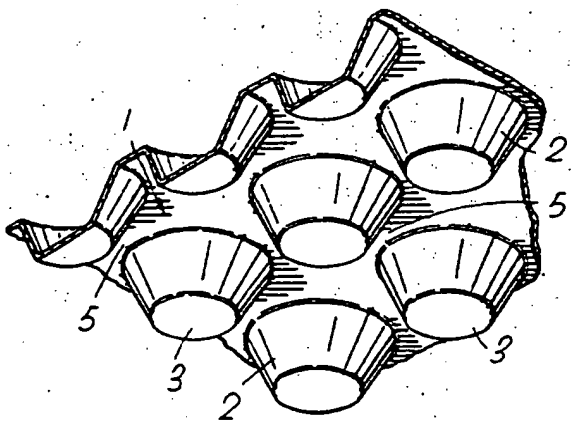


Fig.2.

Fig.3.

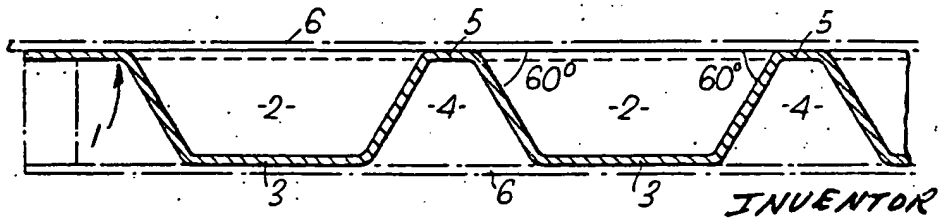


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Fig.8.

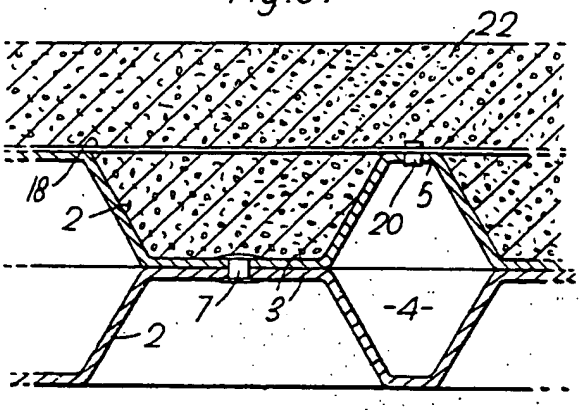

Fig.9.

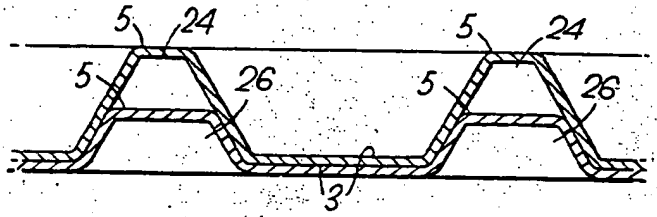

Fig.10.

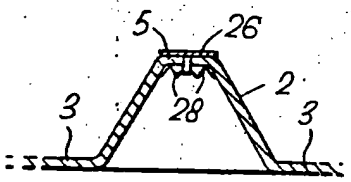

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Fig. 11.

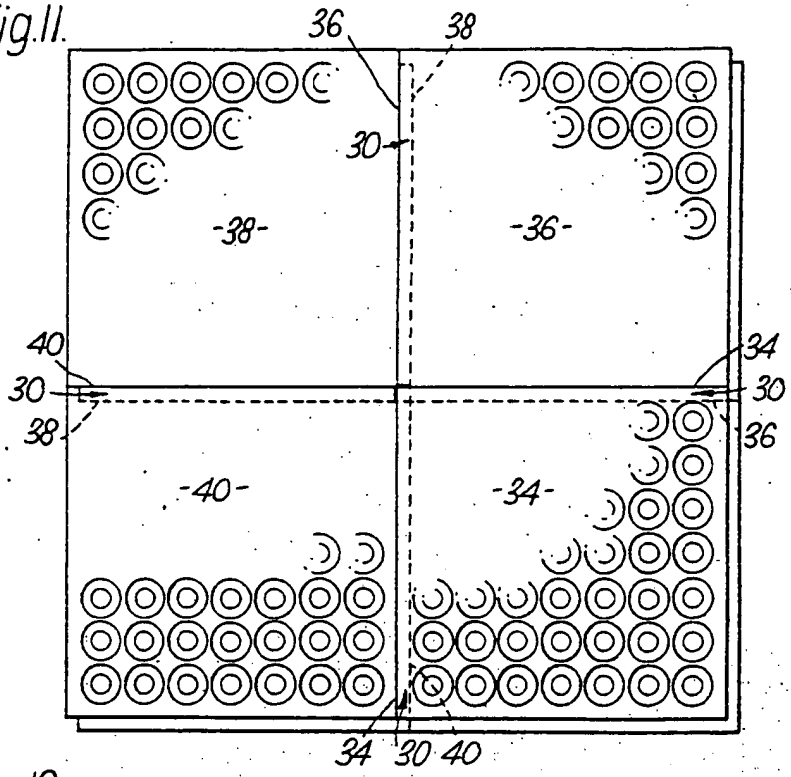

Fig. 12.

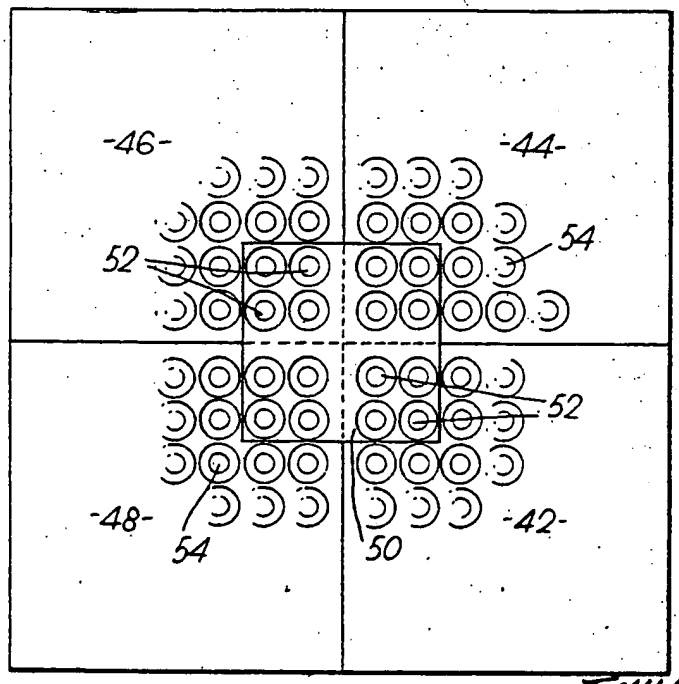

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Fig.4.

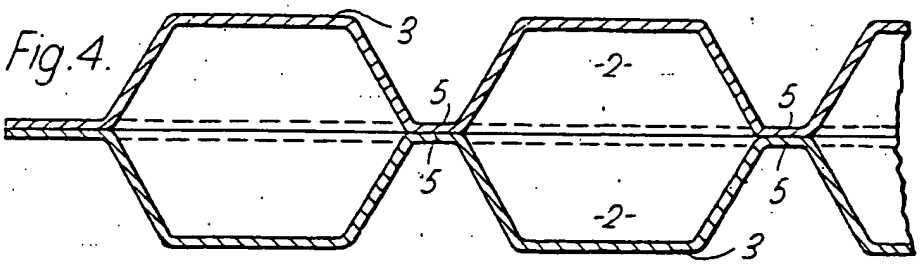


Fig.5.

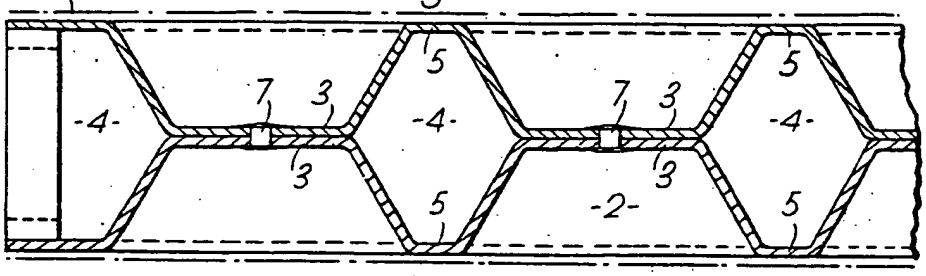


Fig.6.

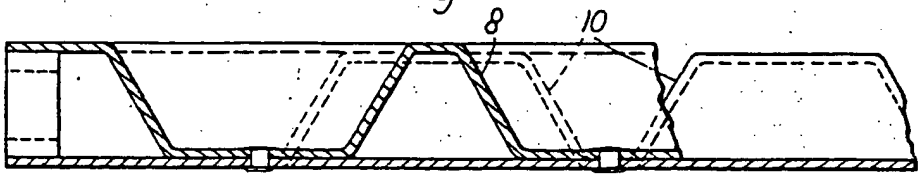
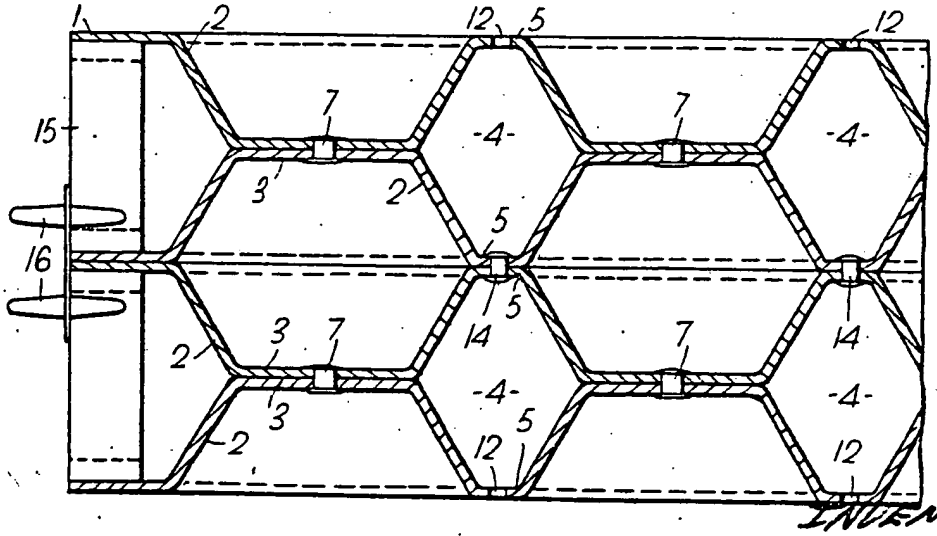


Fig.7.



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